Lunar operations testing in analogue facilities: the ESA-DLR LUNA facility

A. E. M. Casini, P. Mittler, J. Schlutz, T. Uhlig, B. Fischer

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Outline

Topics

- Introduction
- Why LUNA?
- LUNA features
- Project schedule
- Conclusions

International context

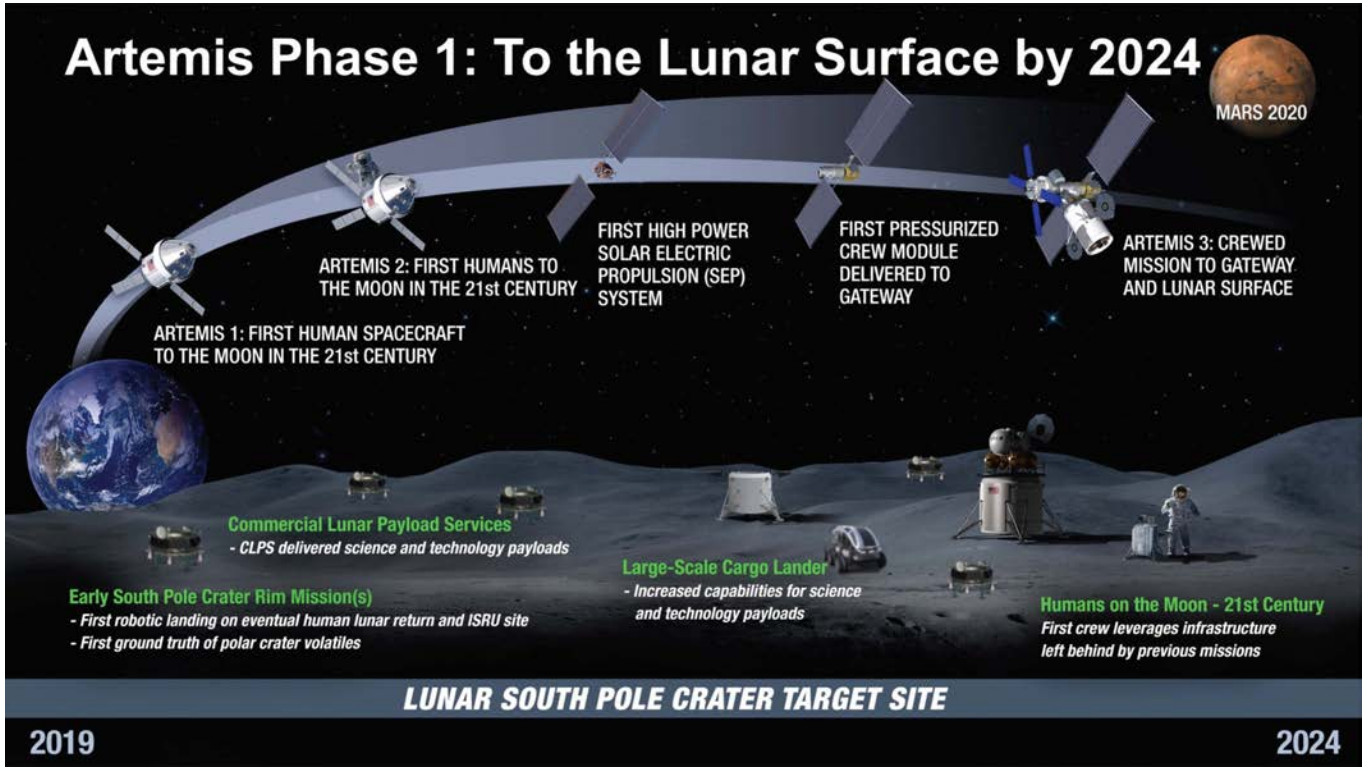
Renaissance of lunar exploration: robotic missions (USA, China, Japan, Russia, India, Korea, etc.) as well as human spaceflights (US Artemis, China/Russia ILRS).

Great interest in LUNA as

- Training/validation facility (closing gap between lab tests and outdoor field tests)
- Potential competence centre for human-robotic operations
- Synergies with European ESA and member states' facilities and industrial partnerships, e.g. ESRIC (LU), ECSAT (UK), COMEX (FR), Air Liquide (FR/DE)

European ambition

- Train all future Moon astronauts in Cologne
- Provide full mission simulation on ground
- Enable robotic system validation and ops
- European astronaut on the Moon bef. 2030



Why LUNA?

Closing gaps (field vs lab)

LUNA will be a unique worldwide facility that addresses the testing and simulation needs of the forthcoming lunar exploration missions

ASTRONAUTS

SPACE FLIGHT EXPERTS

ACADEMIA

INDUSTRY

OPEN PLATFORM EASY ACCESS

START-UPs

PUBLIC

INSPIRATION

KNOWLEDGE

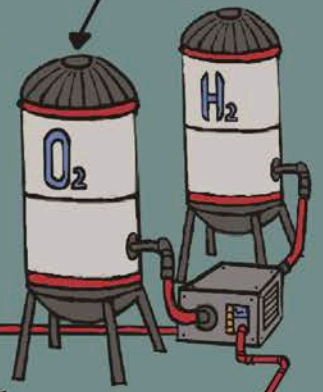
TECHNOLOGY

Multipurpose Rooms

Visitors area

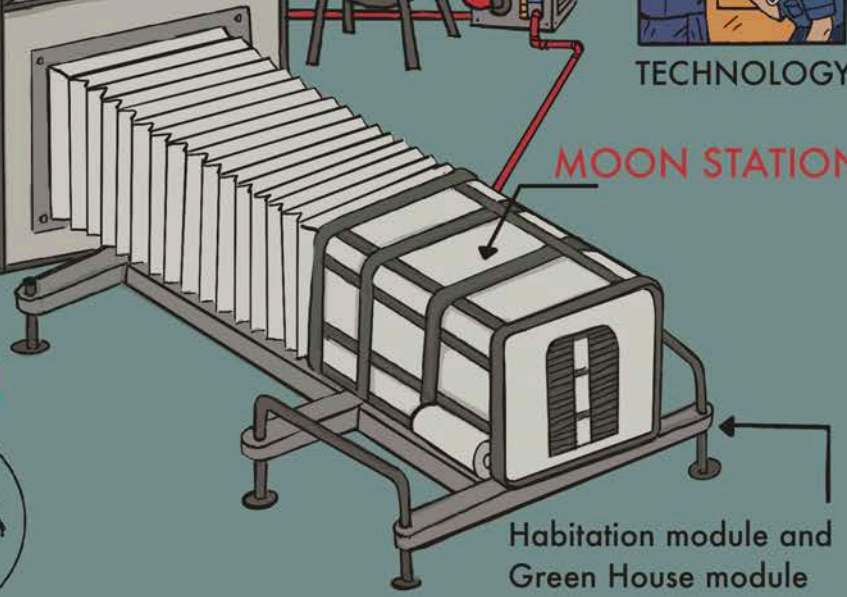
MOON SURFACE simulation area

ENERGY



Mission Control

MOON STATION



LUNA EVOLUTION

LUNA

esa

DLR

Experiment Preparation Area

Habitation module and Green House module

LUNA features

Material Physics

MUSC

Institute for Aerospace Medicine

Competence Centre Aerospace Medicine

:envihab

Solar furnace

LUNA

LUNA

European Astronaut Centre

LUNA features

- Reduced gravity
- Solar illumination simulation
- Dust laboratory
- Gas laboratory
- Terrain modeling
- Positioning / motion capture
- Human-robotic interaction
- Regenerative power systems
- Local comms networks
- Innovative construction
- Virtual reality (VR/AR/XR)
- Outreach & education

LUNA features

Gravity offload system

Goal

Simulation of lunar gravity for astronaut teams (motion, work context, etc.) and for testing of robotic systems (rover, etc.)

Implementation

Unique robotic system to partially offload Earth's gravitational force (Moon = 1/6 g) within the LUNA hall (ceiling or wall mounted)

Dedicated development or combination of robotics, constant force mechanism(s), stage installations, exoskeleton

Utilisation / Unique Selling Point

Unique system, not available on Earth in this performance and scale

Testing of space suits, procedures, equipment, tools, operations concepts and training under realistic conditions

LUNA features

Regolith testbed area

Goal

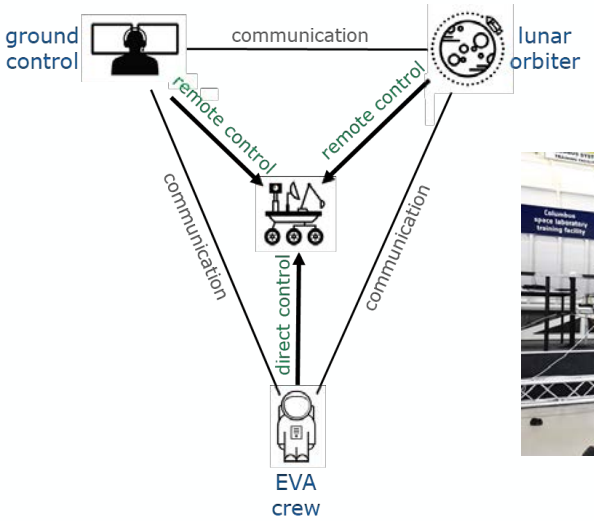
Simulation of lunar terrain for EVA and robotic system training and testing

Implementation

700 m² of lunar terrain replica with a deep floor area and tilting platform, including realistic illuminations (Moon polar and equatorial regions)

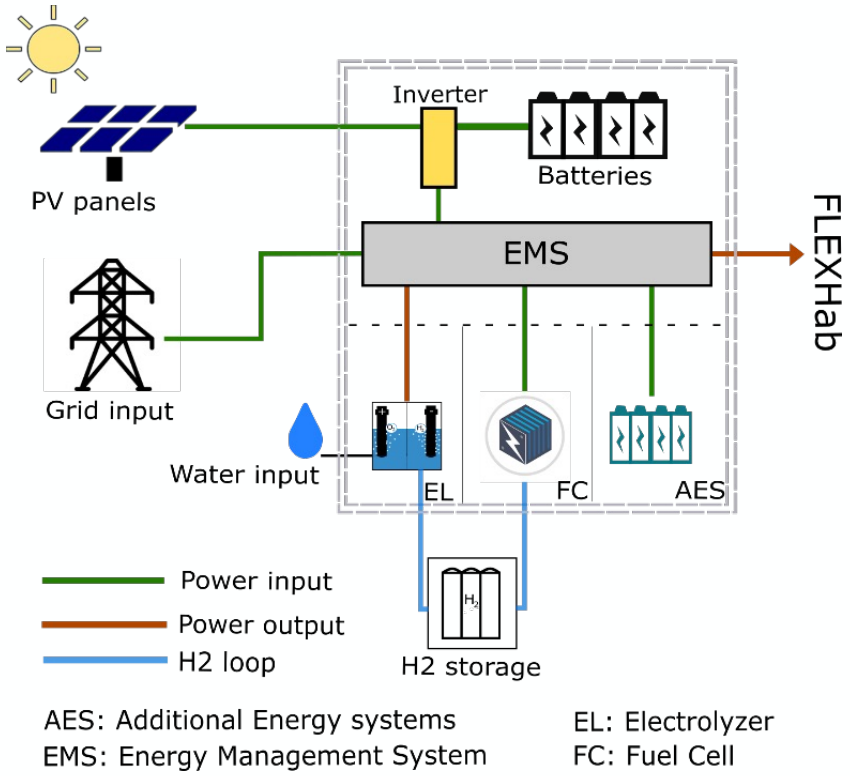
Utilisation / Unique Selling Point

Testing of lunar operations for astronauts and rovers in a closed and controlled environment, including ground segment and ground control infrastructures and XR technologies, also leveraging from the Multi-purpose Astronaut Rover Interaction (MARVIN) project



LUNA Energy

LUNA will have a demonstrator of a hybrid solar-hydrogen stand alone power system aimed at understating how such system can be operated on the Moon



Components and partners:

- PV panels, batteries and inverters (SOLARWATT);
- Fuel cell, container, H_2 storage (Air Liquide);
- Electrolyzer (DLR Stuttgart);
- Energy Management System (RheinEnergie);
- Grid connection is foreseen for simulation and maintenance purposes
- Additional energy systems can be installed for testing
- Gas processing and handling in connection with ISRU experiments

Project schedule

Timeline of the project:

- LUNA has been fully conceptualised (2017-2021)
- Initial funding for construction confirmed by both partners ESA and DLR
  - Indications of other partner contributions available
  - Construction by ESA, planned to start in fall 2022
- Since 2019 discussions with NRW on funding support for technical outfitting and operations of 5 years
- Readiness for operations expected in summer 2023

Conclusions

LUNA is collaborative ESA-DLR project aimed at establishing a European moon analogue facility for preparing lunar exploration with international partners, embedded in the Cologne campus

- Technology and innovation for space and terrestrial applications (e.g. robotics, AI, resources, energy, XR, etc.)
- Training and operational procedures in collaboration with regional and international partners
- Scientific research and knowledge transfer for industry, startups, research institutions, education and outreach
- Low-barrier entry for diverse users and international relevance (incl. NASA Artemis programme)

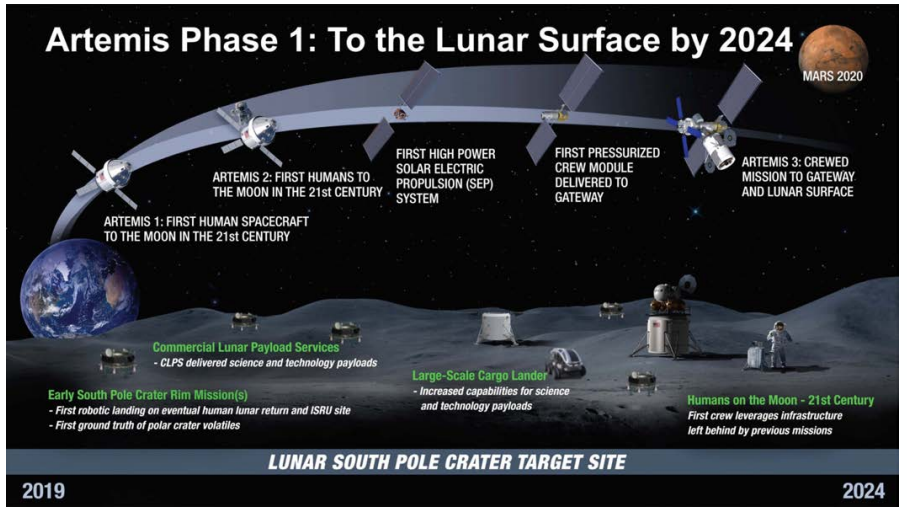

DLR
esa
THANK YOU AND SEE YOU SOON AT ESA-DLR LUNA FACILITY IN COLOGNE!
More questions?
Want to get in touch?
Email to:
andrea.casini@dlr.de
#MoonOnEarth

Back up slides

International context

Contacts with NASA:

- Agreement to be signed shortly for Gateway, surface operations group and human lander group for exchanging XR assets and hours of utilization of LUNA
- Main discussion had with JSC (EVA group, Eddy Paddock), KSC (Swampworks, Robert Mueller) and JPL (Brent Sherwood)
- Following LEAG guidelines (analog-objectives-report-02142022.pdf (usra.edu))



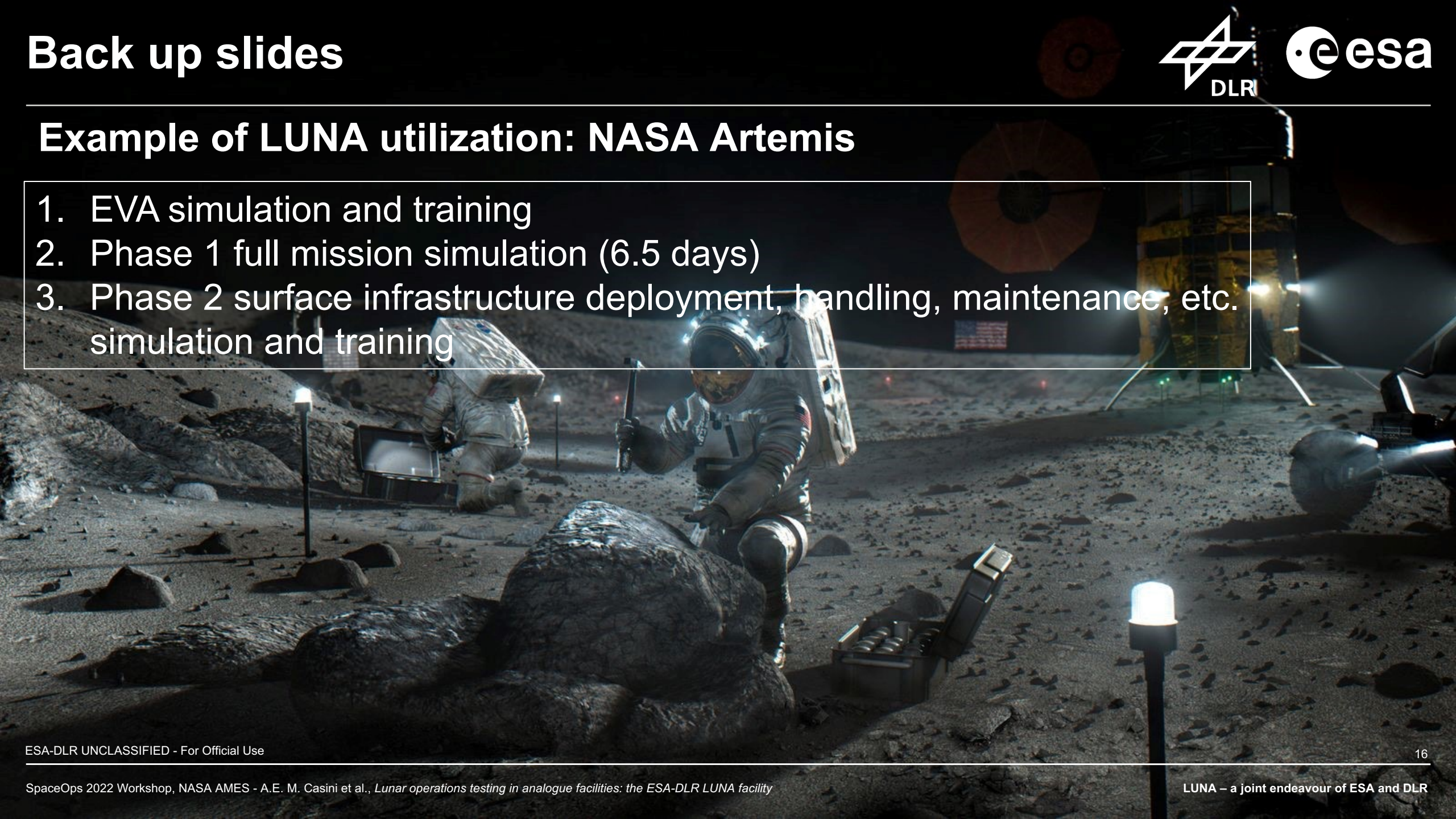
Other contacts:

- External industrial partners have expressed their interested for utilizing LUNA (e.g. Air Liquide, Space Applications Services, TAS, etc.)
- Complementary testing capabilities of other EU centres (ESRIC, etc.)
- Potential playground for challenges and hackathon

Back up slides

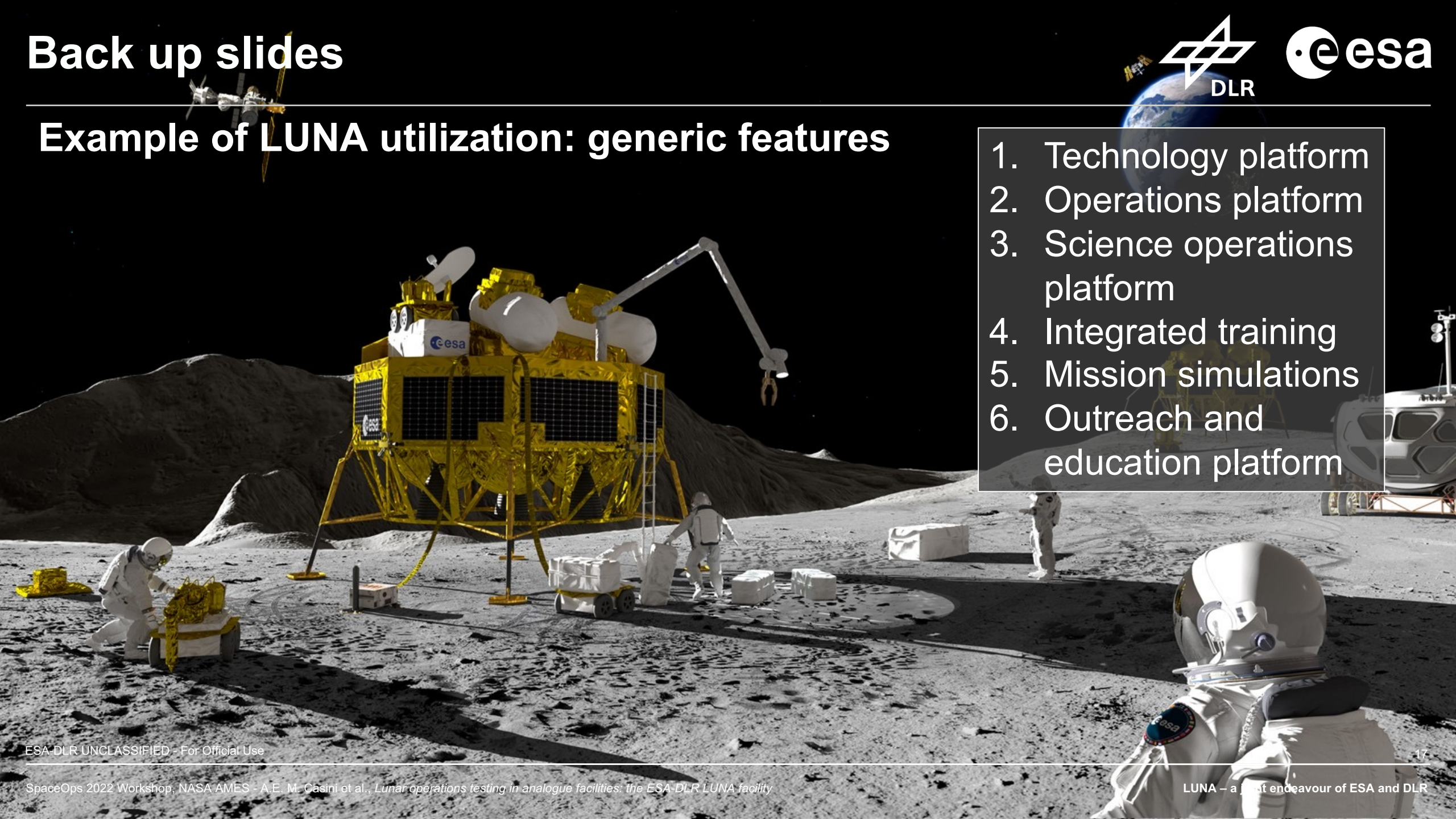
Example of LUNA utilization: NASA Artemis

1. EVA simulation and training
2. Phase 1 full mission simulation (6.5 days)
3. Phase 2 surface infrastructure deployment, handling, maintenance, etc. simulation and training



Back up slides

Example of LUNA utilization: generic features



1. Technology platform
2. Operations platform
3. Science operations platform
4. Integrated training
5. Mission simulations
6. Outreach and education platform